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Analytical Technique Permits Comparison of Reliability of Alternate Mechanical Designs

The problem:

It has not been possible to compare alternate mechanical designs solely on the basis of generic reliability, as is done with electronic designs. Through many years, data have been accumulated on the "average time to failure" for all types of electronic components which enables the estimation of "time to failure" for given electronic design in terms of number and types of electronic components. A technique is required which would enable the comparison of mechanical designs on the basis of inherent reliability.

The solution:

All possible failure modes for the mechanical component are identified. An index is computed for each failure mode which relates the failure mode to failure of the mechanical component. The summation of all failure mode indexes is a measure of the potential reliability of the component.

How it's done:

The major factors considered in a Failure Rate Index analysis are:

(a) Number of parts and significant causes of failure modes
(b) Operating environment
(c) Difficulty of removing failure mode causes
(d) Effect of failure on engine performance

To determine a Failure Rate Index for a component consisting of several parts, the failure mode causes for each part should be known. This is derived from the failure mode analysis. The number of significant failure mode causes for each part is an indication of the degree of exposure of each part to possible failure. It follows that a summation of the failure mode causes for all the parts indicates the degree of exposure of the component to possible failure. Assuming that nothing is done to remove the failure mode cause, and that all components operate in the same environment, the degree of exposure would serve as a relative measure of failure rate. To adjust for the variation in operating environment the degree of exposure is multiplied by a severity of environment weighting factor. If the environment is severe with respect to the capability of the parts or materials, or is unknown, the weighting factor would be high. Also, since it is an objective of a development program to remove all failure mode causes, the difficulty of removing the causes should be considered.

Failure mode causes can be thought of as falling into either of two categories: (1) those removable by design and development effort and (2) those resulting from human error or flaws which are removable by quality control effort. A weighting factor is used to adjust the difficulty of removing the failure modes by either of the two general types of effort. In addition, since the effect of all failures is not the same, a weighting factor is used to correct for the effect of each failure mode on component performance. The above can be reduced to the following general statement which forms the basis of the method developed:

Failure Rate Index (FRI) = (Q)(DOR)(E)(SP), where

Q = Number of failure mode causes (or number of exposures)
DOR = Difficulty of removal factor
E = Severity of environmental factor
SP = Factor system performance

The Failure Rate Index for each part is obtained by a summation of the complexity indexes associated with

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each failure mode cause. The failure rate for higher level components or assemblies is a summation of indexes for all parts in the component or assembly. The design having the smallest Failure Rate Index will have the highest degree of potential reliability.

An analysis form has been developed which permits the systematic application of the FRI technique to a wide variety of mechanical assemblies.

Note:

Inquiries concering this innovation may be directed to:

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No patent action is contemplated by AEC or NASA.

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